



March 4, 2021

VIA ELECTRONIC FILING

Ms. Marlene H. Dortch, Secretary
Federal Communications Commission
45 L Street, NE
Washington, DC 20554

Re: *Ex Parte* Presentation, *Expanding Flexible Use of the 3.7-4.2 GHz Band*, GN Docket No. 18-122

Dear Ms. Dortch:

CTIA respectfully submits the attached further analysis of flawed claims by the aviation industry regarding the Commission’s determination that the technical rules adopted for the 3.7 GHz Service and the spectral separation of at least 220 megahertz “are sufficient to protect aeronautical services in the 4.2-4.4 GHz band.”¹

After years of consideration of the public record, the Commission—as the expert agency with a deep understanding and interest in ensuring services can coexist—determined that C-Band 5G can operate without causing interference, let alone harmful interference, to its neighbors in the same, adjacent, and nearby bands. Despite the aviation industry’s continued efforts to claim otherwise based on a single, flawed report,² fundamental defects in the RTCA Report persist that aviation refuses to address, and real-world deployments provide evidence that RTCA’s assertions are not supported by sound science. As underscored in CTIA’s latest analysis, correcting for these errors more than negates RTCA’s claims of interference—supporting dismissal of their exaggerated, baseless results.

As CTIA noted previously, RTCA used a testing standard that is more conservative than aviation’s own existing altimeter performance standards—which means altimeters operating to manufacturer specifications could fail *even with no C-Band 5G operations present*. RTCA has also denied access to the

¹ *Expanding Flexible Use in the 3.7-4.2 GHz Band*, Report and Order and Order Proposing Modification, 35 FCC Rcd 2343 ¶ 395 (2020) (“C-Band Order”).

² See RTCA, *Assessment of C-Band Mobile Telecommunications Interference Impact on Low Range Radar Altimeter Operations*, RTCA Paper No. 274-20/PMC-2073 (Oct. 7, 2020) (“RTCA Report”), attached to Letter from Terry McVenes, RTCA, Inc., to Marlene Dortch, FCC, GN Docket No. 18-122 (filed Oct. 8, 2020).



actual test data of altimeter performance that its Report cites, refuses to identify the altimeters tested, and relies on flawed criteria—inconsistent with previous altimeter testing—to argue its case.³ With the many questions already raised about the unrealistic conditions used in the test approach, the underlying data should not be hidden. And transparency is all the more critical here where the wireless industry did not have insight into the development of the RTCA Report.⁴ Without the ability to review and understand the data, neither stakeholders nor the Commission can accept the validity of aviation’s claims.

CTIA’s latest analysis provides further evidence of the shortcomings in the RTCA Report, and identifies conflicting and unrealistic margins and conditions applied to 5G operations as compared to other altimeter analyses aviation has conducted. Indeed, at least 65 dB of exaggerated effects are included in the RTCA Report, which—when corrected—reveal more than sufficient margin for all devices tested. As highlighted in CTIA’s latest presentation, technical errors contributing to the significant exaggeration include:

- ***The RTCA Report used stricter criteria than aviation’s own prior testing.*** AVSI engaged recently in an interference analysis of Wireless Avionics Intra-Communication (“WAIC”), an aviation service that is co-channel to the altimeter band at 4.2-4.4 GHz, which replaces onboard aircraft cabling with wireless radio transceivers to reduce weight.⁵ For WAIC, aviation did not include the testing or safety margins it applied in the RTCA Report. Put another way, for 5G coexistence testing, aviation artificially raised the criteria beyond the criteria used in the WAIC study, even though potential interference could affect the same altimeter band. RTCA has provided no

³ See Letters from CTIA to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122 (filed Oct. 27, 2020; Oct. 30, 2020; Nov. 17, 2020; and Dec. 7, 2020). RTCA identifies as significant that its report is “the only publicly available study for the Commission’s further consideration.” See Letter from Terry McVenes, RTCA, and Dr. David Redman, Aerospace Vehicle Systems Institute, to Marlene H. Dortch, Secretary, FCC, GN Docket No. 18-122, at 2 (filed Nov. 19, 2020). Putting aside that this assertion ignores the multiple technical analyses provided in the record by CTIA debunking RTCA’s claims, a study that refuses to make public its underlying data or even identify the altimeters tested cannot form the basis for new findings on the risk of interference.

⁴ RTCA is an aviation organization with no representation from the wireless industry, and RTCA’s Special Committee 239 (SC-239)—which formed a 5G Task Force to study 5G/aviation coexistence—itself stated “[t]he 5G interference report is envisioned to provide *an aviation industry technical position* for spectrum regulators.” SC-239, Terms of Reference, Rev. 1, at 3 (Dec. 17, 2020), <https://www.rtca.org/wp-content/uploads/2020/12/SC-239-TOR-Rev-1-Approved-12-17-2020.pdf> (emphasis added).

⁵ Update on AVSI WAIC-Radio Altimeter Coexistence Testing, Fourth Working Group Meeting of the Frequency Spectrum Management Panel (FSMP – WG/4), ICAO APAC, Bangkok, Thailand, 29 March – 7 April 2017.



basis for evaluating WAIC and 5G operations differently. And, as noted previously, AVSI publicly disclosed the identity of altimeters under the WAIC test and allowed the publication of test parameters and anonymized test results;⁶ there was no reason not to do the same here.

- ***The RTCA Report artificially exaggerated the interference to the landing aircraft.*** The RTCA Report's analysis of Worst Case Landing Scenario ("WCLS"), meant to assess interference risk to altimeters on landing aircraft, sets out unrealistic and incorrect conditions that are substantially more stringent than those used in the WAIC testing. As detailed in CTIA's analysis, in order for the RTCA Report to be accurate, an impossible landing scenario would have to occur where the landing aircraft is coming in over the runway at a height that exceeds what is allowed by the FAA, rolling at a 20 degree angle, landing on a runway covered in sand or plowed land, with 14 other radio altimeters transmitting on the taxiway with perfect ground reflections, and the 5G base station's entire power pointing in a single beam directly at the aircraft from a structure located such that it would violate FAA rules regarding obstructions to air navigation. These factors reflect unrealistic landing conditions that greatly exaggerate interference levels and, when these errors are corrected, the interference risk purported in the RTCA Report is entirely negated.
- ***A 40-year-old altimeter with test data that does not match other altimeter behavior is driving down results in two of the three usage categories.*** For its Report, RTCA expanded the types of altimeters analyzed beyond any type analyzed in the WAIC study, including a pulsed altimeter that could not have been certified by the Commission in the past 40 years. Even putting aside concerns regarding the age of this device, this altimeter's results do not match patterns exhibited by the other altimeters, and it performed much worse than all others tested. All Category 2 and 3 results are driven by this one altimeter, which appears to be either faulty, or the test conditions did not meet the altimeter manufacturer's guidance. Outlier behavior, not matching other altimeters tested, suggests that this altimeter should not be used in decisions regarding coexistence.

⁶ For the WAIC project, AVSI performed laboratory testing of five altimeters and publicly disclosed the identity of the altimeters under test. Further information on the AVSI test bed setup, evaluation criteria, and anonymized test results for each altimeter was made publicly available through a master's thesis on the WAIC testing. See Joshua Ruff, *Radio Altimeter Tolerance of Wireless Avionics Intra-Communications Systems*, submitted to the Office of Graduate and Professional Studies of Texas A&M University, at 58 (May 2019) ("Five different altimeters were tested: the Rockwell Collins LRA2100, The Rockwell Collins LRA900, the Thales ERT530, the Thales ERT550, and the Honeywell ALA52B"); see also Radio Altimeter Interference Susceptibility Testing Status Update, International Civil Aviation Organization Information Paper (Sept. 2018).



- *RTCA modeled 5G power levels incorrectly.* In addition to the substantial deviations from aviation's prior testing, RTCA significantly boosted the signals used in its test cases (by 11 dB to 14 dB) and applied a further 12 dB of padding not required by aviation standards, all without justification, even though commercial operations are 220 megahertz or more away from the aviation spectrum band.

Finally, as detailed in the further analysis, domestic and international 5G deployments serve as a real-world test case demonstrating the successful coexistence of C-Band 5G operations and radio altimeters—further undermining RTCA's claims. As CTIA previously explained, applying the RTCA Report's approach to existing radio operations in the vicinity of the 4.2-4.4 GHz band, several existing systems and services (including very high powered federal systems below 3.65 GHz and ground-to-air communications in the adjacent 4.4-4.94 GHz band) would exceed the purported interference tolerance threshold, yet none of these existing services have been shown to contribute harmful interference to radio altimeters. Similarly, 5G has been deployed across the globe without impacting altimeter operations. Notably, some 90,000 5G base stations have been deployed in Japan with operations up to 4.1 GHz, which is a 100 megahertz guard band from radio altimeter operations—less than half the separation that C-Band 5G operations in the U.S. will have from these aeronautical devices. The lack of reports of widespread altimeter interference today, both domestically and internationally, is further evidence that RTCA's conclusions are critically flawed.

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Given aviation's refusal to make test data public or identify altimeters that were tested, its inconsistent testing parameters as applied to 5G, and the lack of real-world evidence of interference where C-Band 5G and other systems have been deployed, CTIA urges the Commission to disregard the RTCA Report.

Pursuant to Section 1.1206(b) of the Commission's rules, a copy of this letter is being electronically submitted into the record of this proceeding. Please do not hesitate to contact the undersigned with any questions.

Sincerely,

/s/ Kara Graves

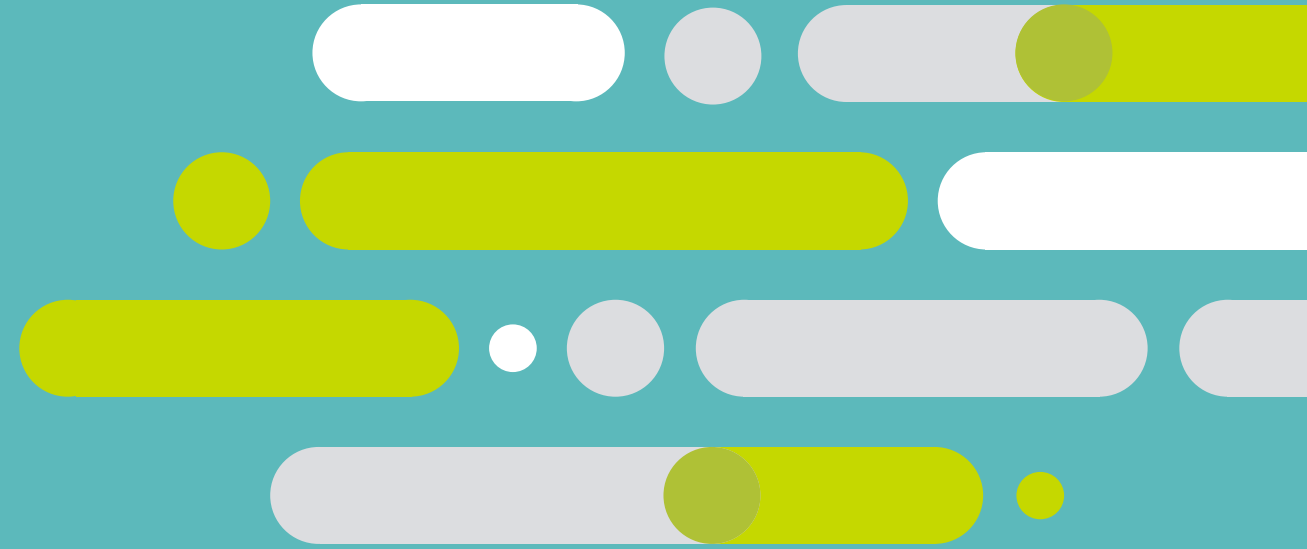
Kara Graves

Assistant Vice President, Regulatory Affairs

Doug Hyslop

Vice President, Technology and Spectrum Planning

Attachment



Altimeter Performance and the RTCA Study

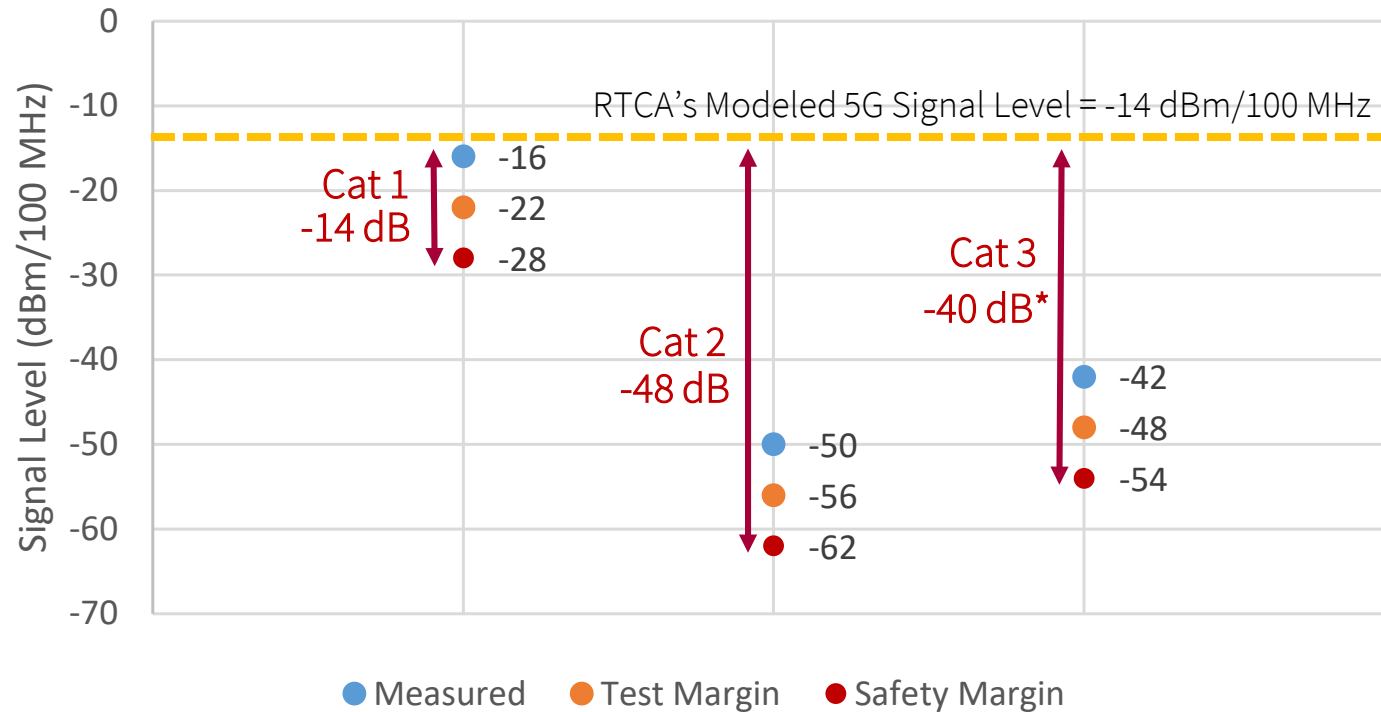
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The RTCA Study is Flawed

- Although transparency is paramount for a fact-based engineering analysis, aviation has refused to share the identity, individual performance, and technical information for the altimeters tested.
- RTCA used unrealistic margins and conditions in its Report. The Report's stringent conditions deviated significantly from those aviation used in evaluating a wireless system installed in aircraft and operating in the same spectrum band as altimeters. The unreasonably stringent assumptions artificially created 5G interference where none exists.
- The underlying AVSI test data for Worst Case Landing Scenario (WCLS) makes duplicitous use of a key parameter, creating unrealistic landing conditions that greatly exaggerate interference levels and significantly underestimate the real-world altimeter signal levels.
- Category 2 and 3 results are due to one poorly performing outlier altimeter, which was not certified within the last 40 years and exhibits odd behavior not matching other altimeters tested.
- Correcting for these errors more than negates all of RTCA's claims of harmful interference.
- 5G is successfully being deployed internationally with a smaller guard band than will be present for the United States C-Band 5G, further undermining RTCA's claims.

RTCA's Claims from October 2020 Report

RTCA Study's Claimed Exceedance at 200 ft



RTCA Report considered three classes of aircraft:

- Category 1: Commercial transport
- Category 2: Business and general aviation
- Category 3: Helicopters

*Cat. 3's highest claimed exceedance of 45 dB was at 2,000 ft. Cat. 3 at 200 ft had a claimed exceedance of 40 dB.

Aviation Has Not Applied the Same Standards to Its Own Service and to 5G

- Wireless Avionics Intra-Communication (WAIC) is an aviation service, co-channel to the altimeter band, which replaces aircraft cabling with wireless radio transceivers to reduce weight.
- In WAIC studies, AVSI only tested Category 1 aircraft altimeters.
- WAIC signal levels were predicted to be 6 dB below the altimeter's measured interference threshold.
- Aviation did not include testing or safety margins in reaching their safe determination, in contrast to those used in its 5G study.
- Indeed, AVSI characterized its results as including 10-12 dB of further margin given the conservative approach, relative to real-world landing scenarios.

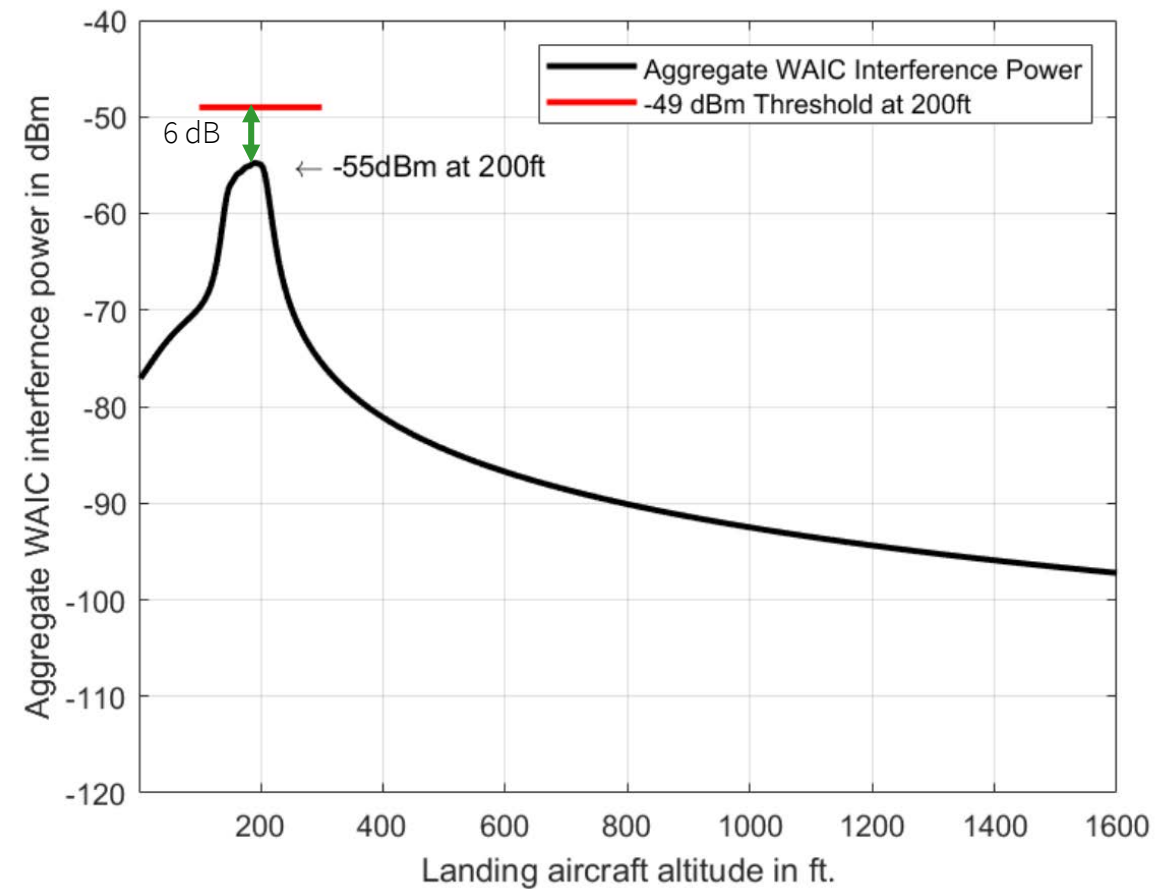


Figure 17: Aggregate WAIC interference power

Source: AVSI WAIC test report submitted to ICAO in August 2019. Green arrow and "6 dB" added by CTIA. Note that WAIC interference is co-channel to the altimeter operating frequency.

Unjustified Margins Added to RTCA Report

- In WAIC testing, AVSI did not include a test margin or safety margin on top of the test results.
- However, AVSI included a 6 dB testing margin in its 5G analysis (a band several hundred megahertz away).
- RTCA added a further 6 dB of safety margin to the thresholds provided by AVSI.
- Aviation applied 12 dB of margin in spite of the large guard band – margin deemed not necessary for WAIC, *a service operating co-channel to (in the same spectrum band as) the altimeters.*

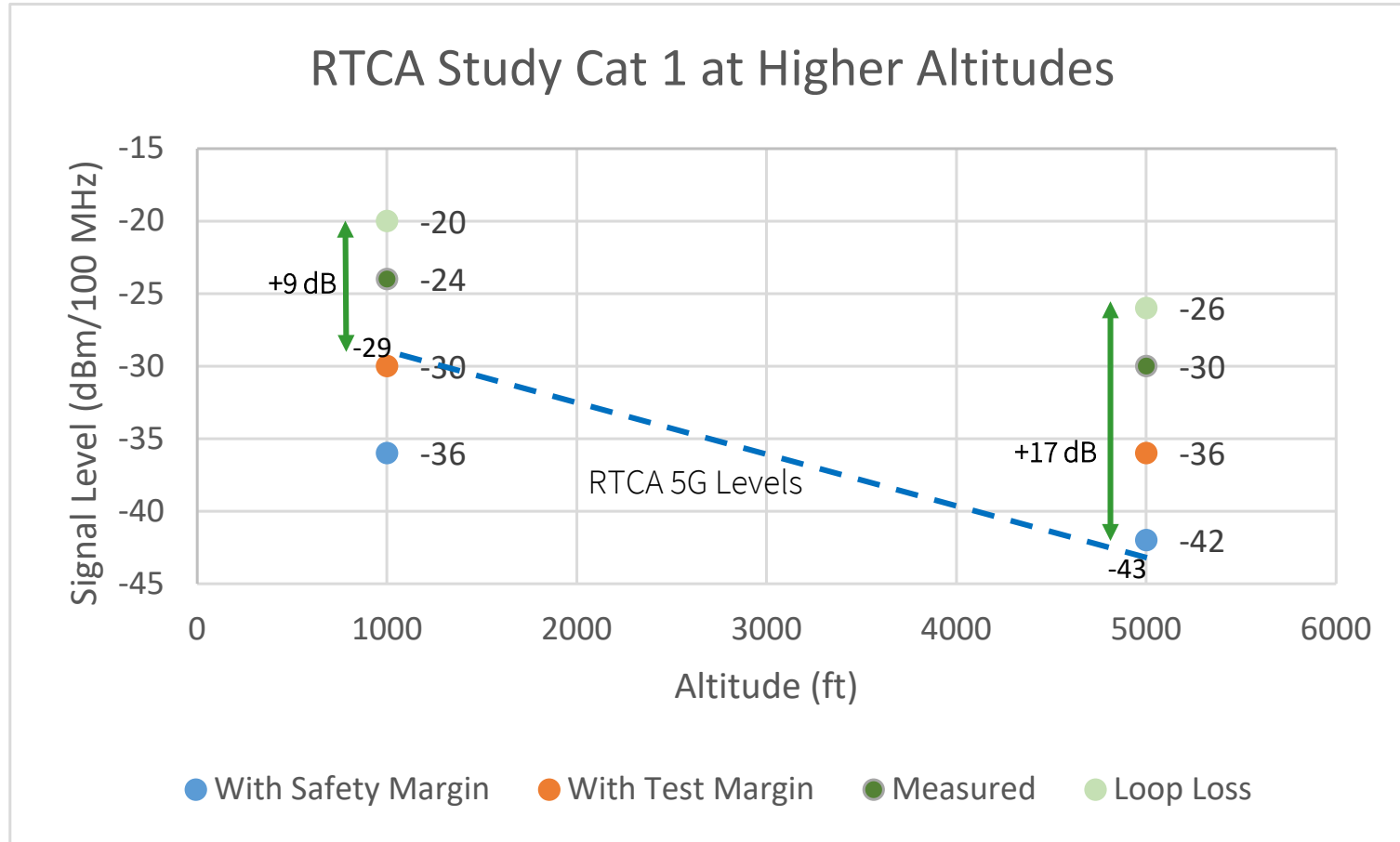
Cable Loss and Loop Loss

- A radio altimeter transmits a signal toward the ground, and measures the reflected signal's time delay to determine the distance above ground.
- The Loop Loss defines how much of the signal is reflected back to the altimeter receiver, versus scattering elsewhere.
- Signals experience more scattering over rough terrain than smooth terrain. Higher Loop Loss means less energy is reflected back to the altimeter receiver, making it more difficult to measure the altitude.
- RTCA DO-155, aviation's standard for altimeter performance, does not require cable loss to be included in the lab test setup, calling for a worst case loop loss of 90 dB at 200 feet.

Study Input	RTCA DO-155 Requirement	AVSI's WAIC Testing	AVSI's 5G Testing	Delta
Loop Loss at 200 ft	90 dB	92 dB	96 dB	6 dB

- AVSI used 92 dB for WAIC testing, choosing 90 dB for loop loss and 2 dB for test setup error. AVSI noted that DO-155 does not require the use of cable loss, and therefore did not include cable loss for WAIC.
- With 5G, AVSI added 6 dB of cable loss to the lab test setup. The test condition was arbitrarily worse for 5G than for WAIC, and worse than DO-155 guidance.

Example: Correcting Category 1 Altimeter Results to Match WAIC Study

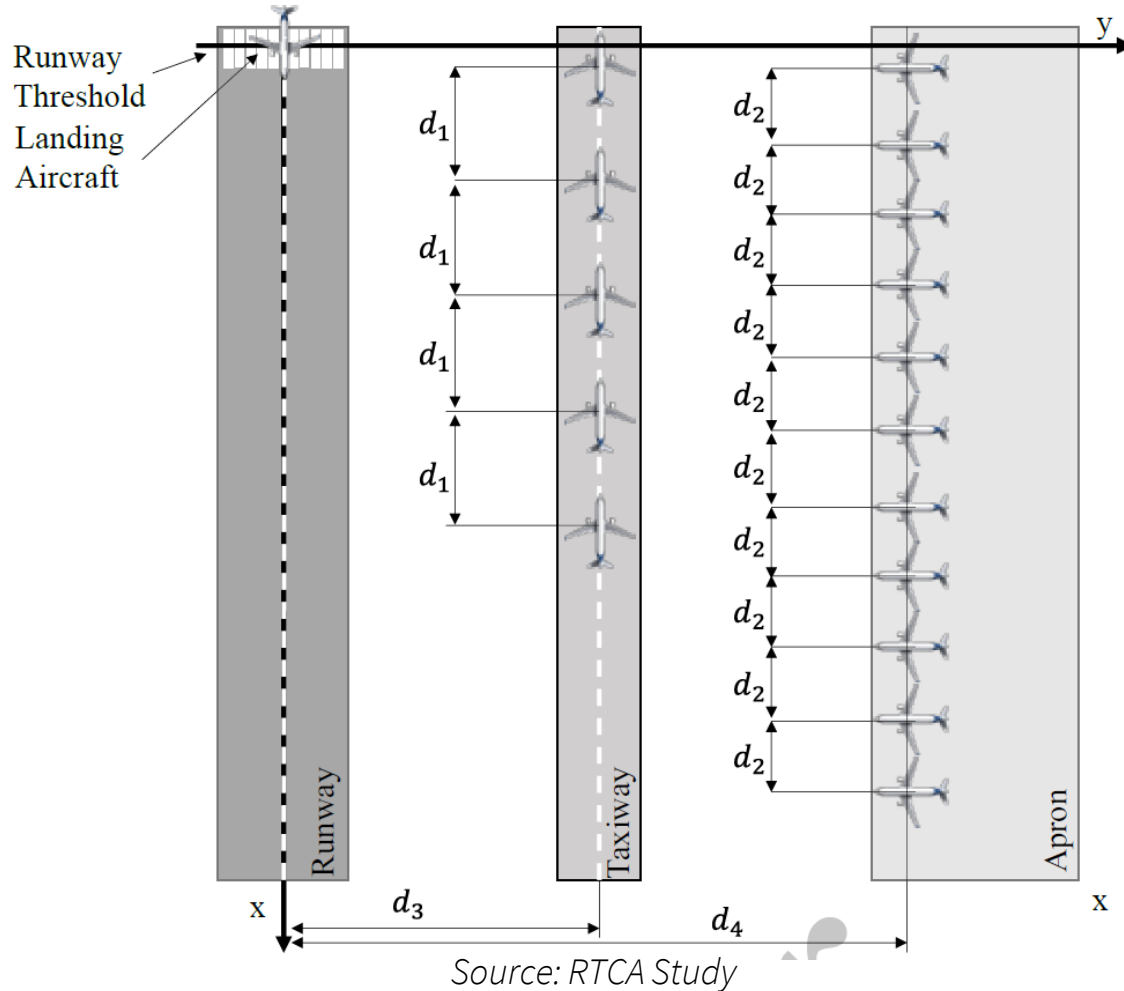


- This figure shows the RTCA Report results for Category 1 at 1,000 and 5,000 feet, adjusted to match the WAIC conditions.
 - “Measured”: AVSI test results
 - “With Test Margin”: Aviation added 6 dB
 - “With Safety Margin”: Aviation added 6 dB
 - “Loop Loss”: AVSI used 4 dB worse value than assumed in WAIC testing.
- RTCA’s modeled 5G levels, shown by the blue dashed line, are 9 to 17 dB below the worst Category 1 altimeter’s adjusted overload threshold.

At these altitudes, all Category 1 altimeters have more cushion than in the WAIC determination, which aviation deemed safe. Aviation artificially raised the criteria for 5G to show interference.

Worst Case Landing Scenario Assessment

Worst Case Landing Scenario (WCLS)



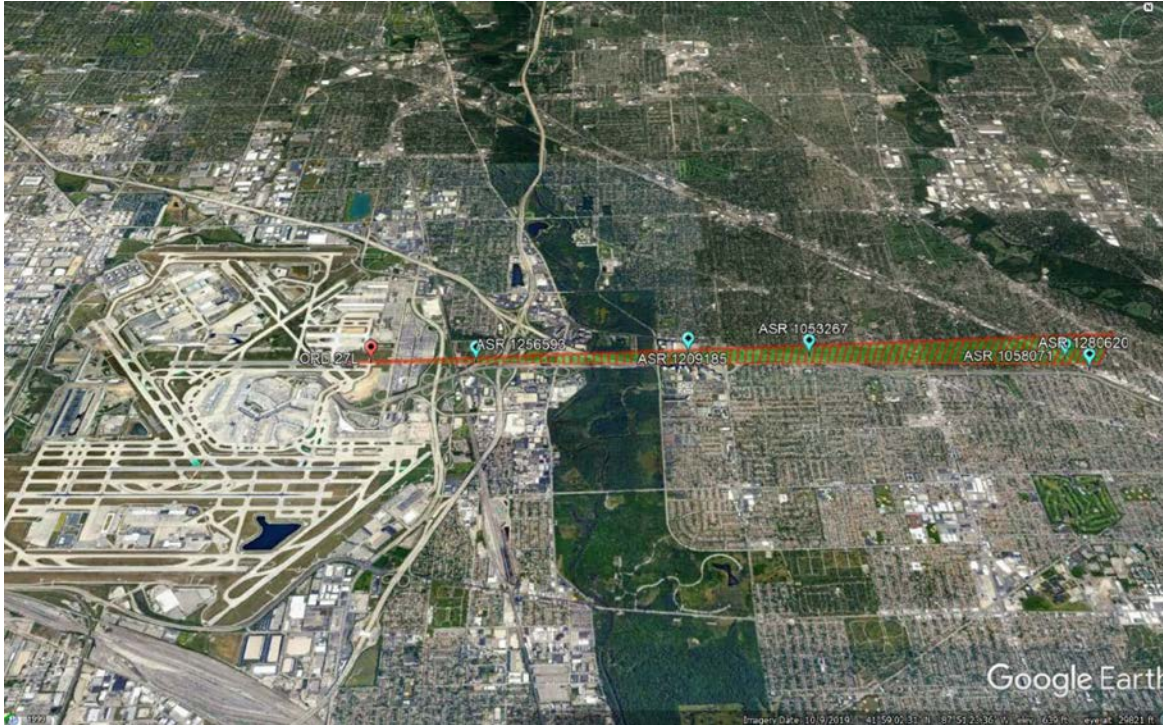
WCLS is meant to assess interference risk to landing aircraft.

WCLS is not described in aviation MOPs defining altimeter performance. Rather, it was designed by aviation with several unrealistic conditions:

1. Altitude of 200 feet for a landing aircraft over the runway threshold is incorrect.
2. Altimeter interference from a large number of aircraft on the ground is not required by DO-155.
3. Rough terrain over the runway threshold is incorrect.

These three factors greatly exaggerate the WCLS interference conditions.

Landing Altitude Over the Runway Threshold is ~50 Feet, Not 200 Feet



RTCA's Chicago O'Hare landing description:

“The flight path is defined based on the approach plate shown in Figure 8-2, which indicates a 3.00° glide slope angle (GS), an approach magnetic heading of 273° (corresponding to a true heading of 270°), and a final approach fix occurring at 2,200 ft barometric altitude (corresponding to about 1,550 ft AGL) at a distance of 4.7 nautical miles (NM) from the runway threshold.” *RTCA Report*

With a 3 degree glide slope, the aircraft altitude over the runway threshold is 53 feet.

FAA Threshold Crossing Height (TCH)

FAA Order 8260.3E provides recommended and maximum TCH for all types of aircraft.

The maximum TCH for large commercial aircraft is 60 feet.

Table 10-1-1. TCH Requirements

Representative Aircraft Type	Glidepath-to-Wheel Height (approximate)	Recommended TCH	Remarks
<u>HEIGHT GROUP 1</u> General Aviation, Small Commuters, Corporate Turbojets, T-38, C-12, C-20, C-21, T-1, Fighter Jets, UC-35, T-3, T-6	10 ft or less	40 ft	Normally runways < 6000 long with reduced widths and/ or limited weight bearing, limiting larger aircraft use.
<u>HEIGHT GROUP 2</u> F-28, B-737, C-9, DC-9, C-130, T-43, B-2	15 ft	45 ft	Regional airport with limited air carrier service.
<u>HEIGHT GROUP 3</u> B-727/707/720/757, B-52, C-135, C-141, C-17, E-3, P-3, E-8, C-32	20 ft	50 ft	Runways not normally used by aircraft with ILS glidepath-to-wheel heights > 20 feet.
<u>HEIGHT GROUP 4</u> B-747/767/777, DC-10, A-300, B-1, KC-10, E-4, C-5, VC-25	25 ft	55 ft	Most primary runways at major airports.

Note: To determine the minimum allowable TCH, add 20 feet to the glidepath-to-wheel height and to determine the maximum allowable TCH, add 50 feet to the glidepath-to-wheel height (not to exceed 60 feet).

Aviation's Choice of 200 Feet Makes the RA Interference Artificially Worse

“The impact of the runway threshold crossing altitude for the WCLS geometry was analyzed to determine the worst-case interference level from all RAs in the WCLS. The object was to establish the maximum interference levels from the aggressor RA sources for laboratory testing. In considering the RA interference levels received by the victim aircraft (see Figure 3), the antenna gains, free-space path losses, ground bounce geometries, and aircraft structural shading were considered. From the various altitudes analyzed, **an altitude of 200 ft produced the highest level of aggregate external RA interference to the victim aircraft.** Therefore, this altitude was considered as the worst-case for further analysis, including the additional impact on RA performance caused by WAIC emissions from the sixteen aggressor aircraft.” – AVSI WAIC Report at 6 (August 2019) (emphasis added)

- Aviation used 200 feet because the worst case interference from other RAs on the ground is highest at that aircraft height.
- However, 200 feet is not a realistic altitude for a landing aircraft over the runway threshold; 50 feet is the realistic altitude.
- Based on the altimeter antenna pattern, at the lower height, the Other RA interference to the landing aircraft would be 5-10 dB less.
- **The WCLS must use 50 feet as the realistic landing aircraft altitude over the threshold.**

Correcting Loop Loss, Cable Loss, and Rough Terrain

- RTCA DO-155 defines the worst-case laboratory testing conditions to use in characterizing altimeter performance:
 - The loop losses are worst case over rough terrain, and include sufficient margin to account for pitch and roll within the aircraft altimeter antenna's 3 dB beamwidth.
 - DO-155 does not include cable losses in the lab test setup.
 - DO-155 states that runways are considered smooth terrain (App. A, p. 5).
- Four corrections are necessary to accurately portray real-world WCLS conditions:
 1. Adjust loop loss from 200 feet to 50 feet for the real landing altitude: 16 dB improvement.
 2. Adjust loop loss from rough terrain to smooth terrain: 15-20 dB improvement.
 3. Do not add cable losses per DO-155: 6 dB better (applies to all altitudes).
 4. Reduce Other RA interference for the 50 feet height: 5-10 dB lower.

The correct WCLS conditions would be 42 to 52 dB better than what AVSI tested.

Appropriate Lab Test Setup and Conditions

- Lab test setup should include the altimeter indicator (pilot's display) for end-to-end assessment.
- Other appropriate lab inputs and conditions include:

Test Input	Altitude = 50 ft	Altitude = 200 ft	Altitude = 1,000 ft	Altitude = 2,000 ft
"Other RA" Interference	Yes	No	No	No
Terrain under aircraft	Smooth	Rough	Rough	Rough
DO-155 Loop Loss	54 dB	90 dB	104 dB	110 dB
DO-155 Pilot's Display Tolerance	+/- 5 ft	+/- 5%	+/- 7%	+/- 7%
Test Margin	0 dB	0 dB	0 dB	0 dB
Safety Margin	0 dB	0 dB	0 dB	0 dB

5G Power Level Assessment

RTCA Artificial Inflation of 5G Power Levels: RTCA Section 10

- The RTCA Report modeled 5G power arriving at the aircraft as emitted from a number of base station configurations.
- RTCA section 10 describes the worst case 5G levels occurring when an aircraft flies over a base station:

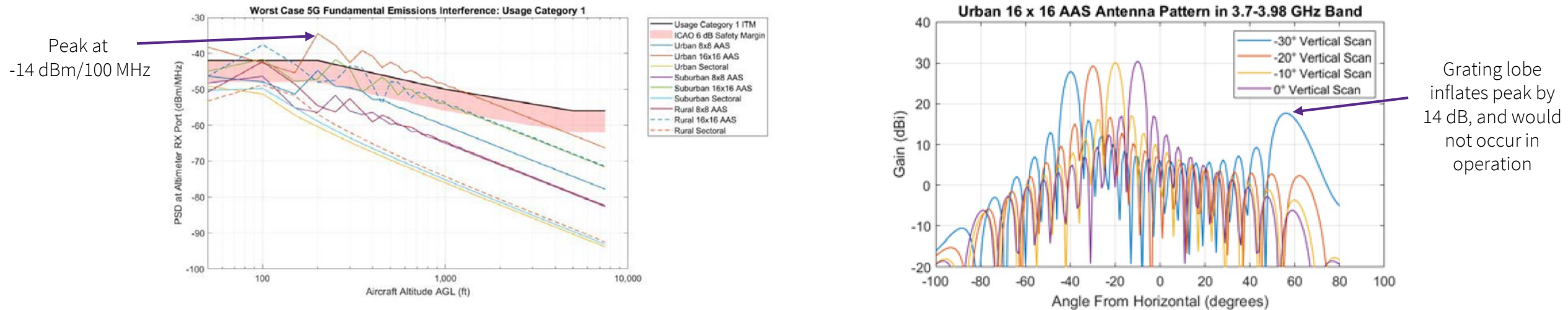


Figure 10-3: Maximum 5G Fundamental Emissions Levels, Usage Category 1

- CTIA commented during the adjudication process that the peak power level is due to an error in the assumed beamforming, which produced a grating lobe. An operating base station would not scan below horizon as sharply as assumed, and would not create this grating lobe toward the sky.
- The correct 5G power level at the aircraft would be 14 dB below the level used by RTCA in Section 10 of the Report.

Additional RTCA Modeling of 5G Power Levels: Appendix D

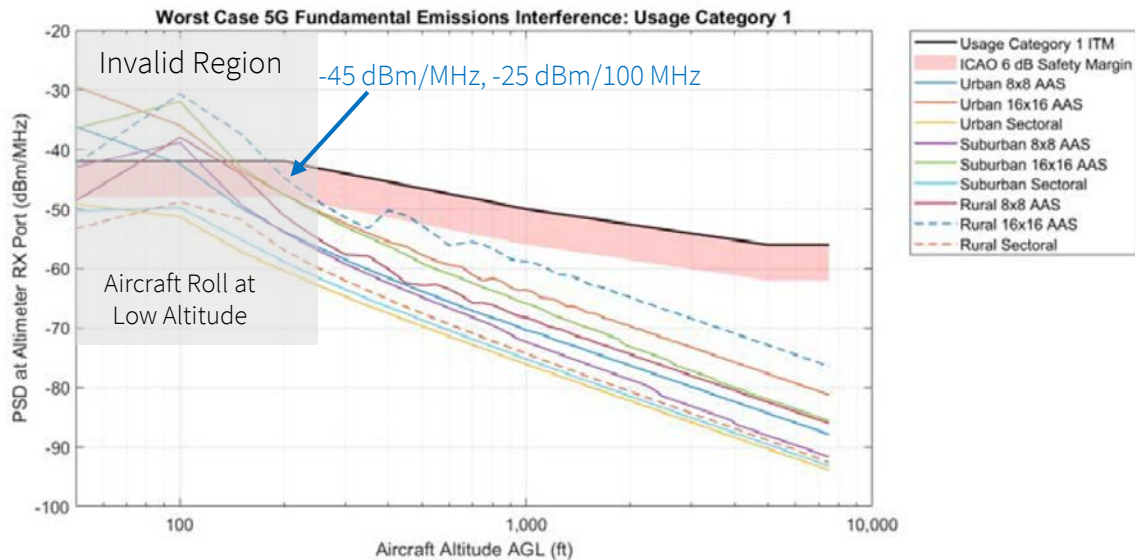


Figure D-3: Maximum 5G Fundamental Emissions Levels, Usage Category 1

“Although most operations of Usage Category 1 aircraft at low altitudes will not involve significant pitch or roll angles, these scenarios cannot be ruled out entirely. Many takeoff and landing scenarios require low altitude turns (with roll angles of up to 20 degrees) in order to navigate around buildings, terrain, or restricted airspace. One example of this is the approach into runway 19 at Reagan National Airport just outside of Washington, D.C. This approach requires a late turn maneuver just prior to landing in order to avoid Prohibited Area 56 surrounding the White House and the National Mall. [The turn maneuver will typically involve a roll angle of up to 15-20 degrees and conclude with the aircraft at an altitude of about 250 feet AGL.](#)” -- RTCA Report, page 205.

- To address CTIA’s adjudication comments, RTCA performed further modeling of 5G power levels and reported the results in Appendix D.
- Appendix D’s results require a landing aircraft to pitch or roll 20 degrees, which is not a safe maneuver at very low altitudes.
 - RTCA’s example indicates that the aircraft completes the roll at DCA by 250 feet AGL.
 - CTIA added the gray box to denote the invalid regions of the figure due to incorrect aircraft roll below 250 ft.
- Per Appendix D, at 200 feet, the 5G signal level is -25 dBm/100 MHz (see arrow in figure to left).
- Thus, the actual 5G power level modeled by RTCA, at a valid height, is 11 dB lower than the power level RTCA used in their claimed exceedance levels – the claims are overstated.

Correcting the RTCA Study's Errors

Estimating the Adjusted Performance at 50 Feet with WCLS

Input/Condition Adjusted	Amount of Adjustment (dB)
Test Margin	6
Safety Margin	6
Remove Cable Loss per DO-155	6
Loop Loss Correction to 50 ft Altitude	16
Smooth Terrain Correction	15-20
Correct “Other RA” Interference	5-10
5G Power Level Correction	>11
Low End Estimated Adjustment	65

With at least 65 dB of adjustments, the positive margin for the 50 foot WCLS case becomes:

- Category 1: $(-14 + 65) = +51$ dB
- Category 2: $(-48 + 65) = +17$ dB

All nine altimeters would have positive margin under correct WCLS conditions.

No interference to any of the altimeters tested when errors are corrected.

Potentially Misleading Aspects of the RTCA Study

Aviation Shared Altimeter Information in Its WAIC Work, but Not in 5G Work

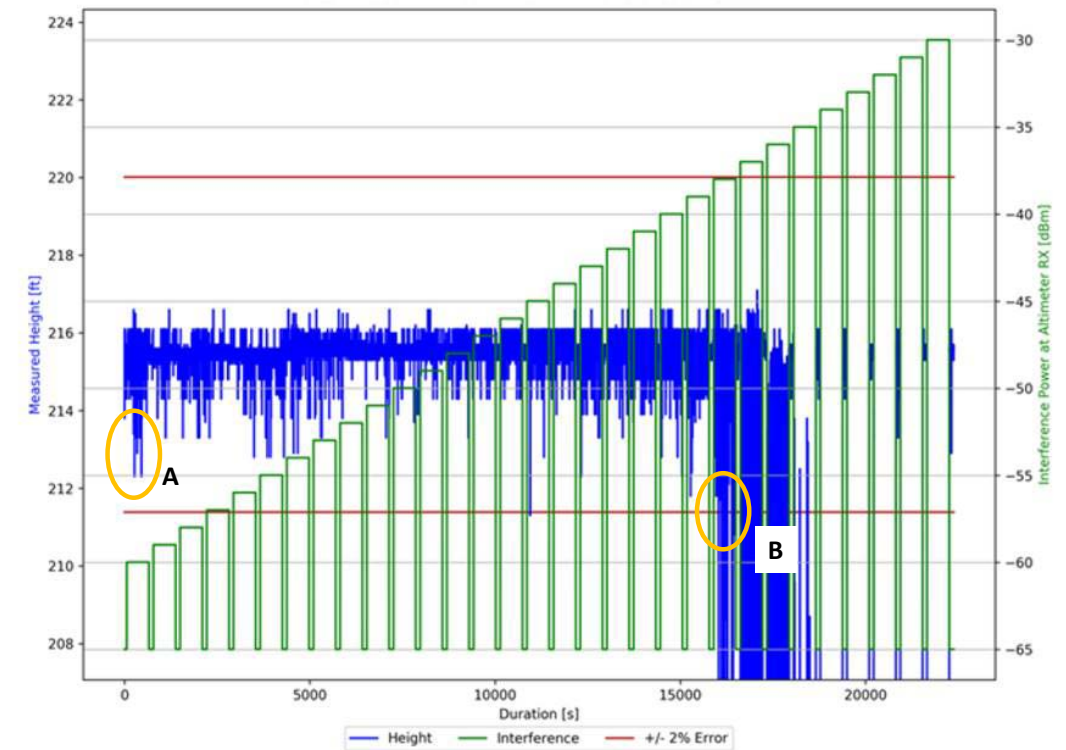
- With WAIC, AVSI identified all altimeters by manufacturer and model number.
 - Honeywell ALA-52B
 - Rockwell Collins LRA-900 and LRA-2100
 - Thales ERT530 and ERT550
- AVSI provided anonymized test data for each altimeter in the WAIC test reports.
- With 5G, aviation has claimed that confidentiality agreements prevent sharing the identity of altimeter models tested, and the test data.
 - The August 2019 WAIC test report was released just two months before the initial AVSI C-Band 5G report was filed in October 2019.

The Report's Pass/Fail Criteria Were More Stringent than Aviation Standards and Manufacturers' Design Tolerance

- AVSI defined “interference” as either a mean error in altitude of 0.5%, or more than 2% of data points exceeding an altitude accuracy of 2%.
- Aviation's altimeter requirements documents note more relaxed tolerances than AVSI's failure criteria:
 - EUROCAE ED-30 describes several classes of altimeter:
 - 1) Category A1: for the needs of automated landing systems. Accuracy is +/- 3% from 100 to 500 feet, and +/- 5% above 500 feet. The pilot's display permits a 2% higher tolerance.
 - 2) Category A2: identical to A1 except that the accuracy is not in accordance with A1, but shall be declared by the manufacturer.
 - 3) Category B: expected to meet the needs of ground proximity warning systems. Accuracy is +/- 5% for 100 feet and above.
 - 4) Category C: altimeter should meet +/- 2% but over smooth terrain. Cat. C is also expected to be certified under A1, A2 or B.
 - DO-155, RTCA's standard for minimum performance of altimeters, also specifies a more relaxed +/- 3% accuracy, and +/- 5% for higher altitudes. The pilot's display permits +/-7%.
- Altimeter manufacturers' specifications are also more relaxed than AVSI's pass/fail criteria:
 - The Thales ERT-530's accuracy tolerance is +/- 5% for the conditions under test.
 - The Bonzer Mark-10, Sperry AA-210, and Hoffman Altiscan pulsed altimeters' accuracy tolerance was also +/-5%, with no terrain type specified.
- Using criteria tighter than the altimeter's designed accuracy guarantees failure - the results are invalid.
- Aviation incorrectly claims that tighter tolerance is needed to ensure 5G does not consume margin for other environmental factors; this is faulty logic, as the test conditions are beyond worst case in all areas.

Threshold Uncertainty Results in Further Unjustified Exceedances

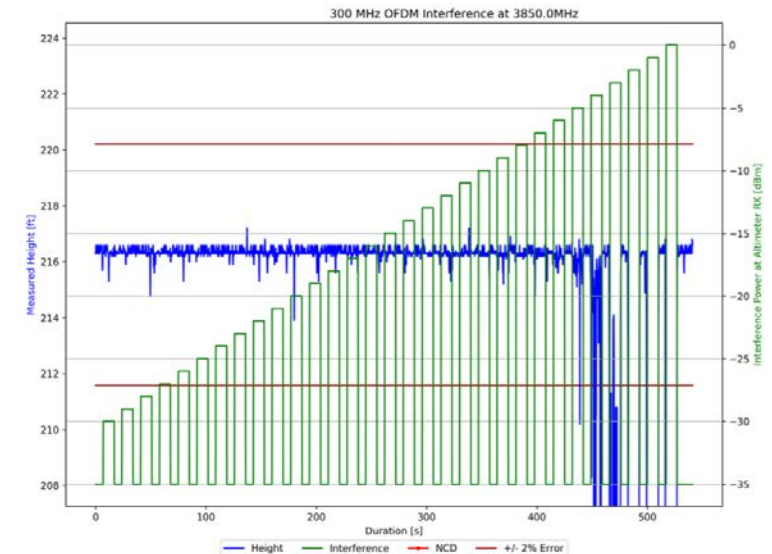
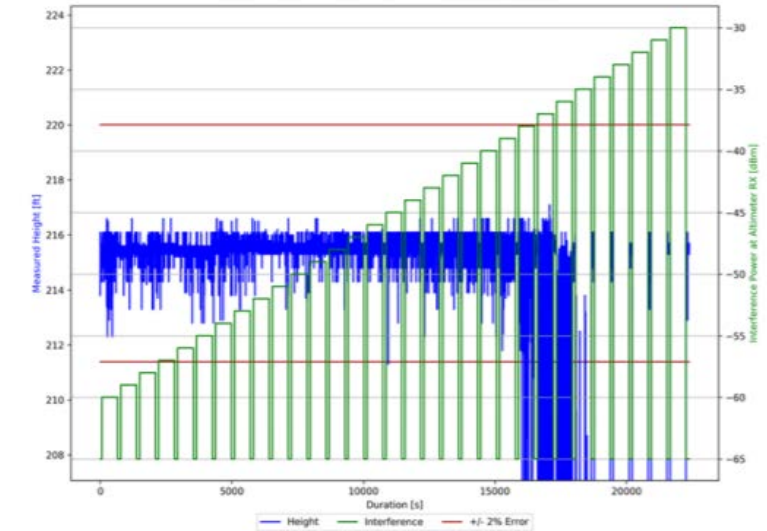
- AVSI does not identify which pass/fail criteria were exceeded in claiming interference, and it does not provide the underlying data to permit third-party evaluation.
- The one power plot provided in the Report (identical to the example in the WAIC report, suggesting the plot is not for a C-Band test) shows what could be a significant delta in interpreting the results – if the $> 0.5\%$ criteria is triggered at point A, versus $> 2\%$ at point B. While both criteria are invalid, this highlights the Report's lack of clarity regarding the test outcomes.
- No conclusion could be reached using this plot for an altimeter designed to a EUROCAE ED-30 tolerance of $\pm 5\%$.
 - The graph's Y-axis does not exceed 4% of the mean height.
 - Threshold uncertainty could be constituting *a large amount of exaggeration*.



Source: RTCA Report (markings for context by CTIA)

RTCA Presented Non-5G Data and Changed Test Durations

- The upper chart is taken from the RTCA Report (page 114), but as noted above actually comes from the WAIC study (page 15) and does not represent 5G results.
- The data in the lower chart comes from AVSI's Interim Interference Report (page 12).
- The duration of testing used for each power level for WAIC testing (10 minutes) does not correspond to the duration of testing for each power level for 5G testing (10 seconds).
- The upper chart is made up of up to 18,000 samples per power level, while the lower chart is made up of at most 300 samples per power level.
 - 5G is automatically penalized under AVSI's thresholds due to the smaller number of samples.
 - The entire test duration for 5G signals is smaller than the duration for a single power step in the WAIC testing.
- A temporary blip in the 5G test, affecting 7 out of 300 samples, would result in a failed test, while the same blip in the WAIC test would be averaged out, with a passing result.



Cat. 2 and 3 Are Driven By One Questionably Poor Altimeter

- RTCA evaluated four altimeters for Categories 2 and 3: Types 6, 7, 8, and 9.
- From earlier test reports, it is clear that either Type 8 or Type 9 is the worst altimeter driving all of RTCA's conclusions in these categories.
- Comparing interference thresholds from the RTCA Report and the Helicopter Air Ambulance study:

Altimeter	Measured Threshold	Source
Type 6	0 dBm	HAA Study
Type 7	-27 dBm	HAA Study
Type 8 or 9	Cat 2: -50 dBm Cat 3: -42 dBm	RTCA Study

- AVSI noted in its February 2020 Supplemental Report that “altimeter Type 7 exhibited a reduced OoBI tolerance threshold compared to the other six RAs tested, and was excluded from the combined ITM plots in Section 5.3.”
- The Type 8 or 9 altimeter is 50 dB worse than Type 6, and 23 dB worse than the previously suspect Type 7 altimeter.
- This worst performer is likely the pulsed altimeter added for the RTCA testing, and was not certified within at least the last 40 years.

Type 8 or 9's Outlier Test Data Does Not Match Other Altimeter Behavior

- Category 3 tests are identical to Cat 2, except the 200 feet measurements in Cat 3 exclude the WCLS RA interference.
- Indications of bad data or a poorly performing altimeter include:
 - Thresholds normally improve with increasing frequency separation – this altimeter performs the worst for 5G signals farthest away (3750 MHz).
 - With Cat 1, the delta between 1,000 and 2,000 feet is less than 5 dB. This altimeter shows 13 dB worse performance for 2,000 feet at 3930 MHz, and 8 to 9 dB for the other two frequencies.
 - The 1,000 foot and 2,000 foot measurements vary considerably across frequencies, much greater than Cat 1.
- Odd behavior, not matching other altimeters tested, suggests that this altimeter should not be used in decisions of aviation safety.

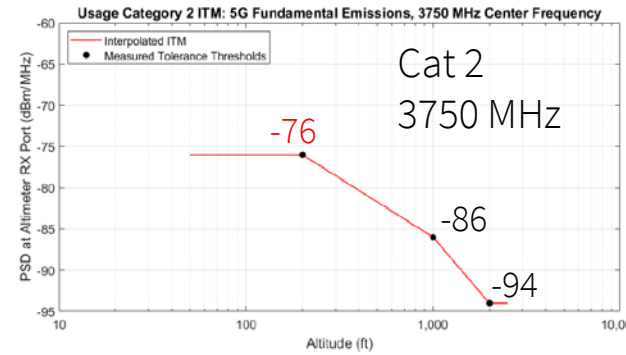


Figure 9-4: Usage Category 2 ITM for 5G Fundamental Emissions at 3750 MHz

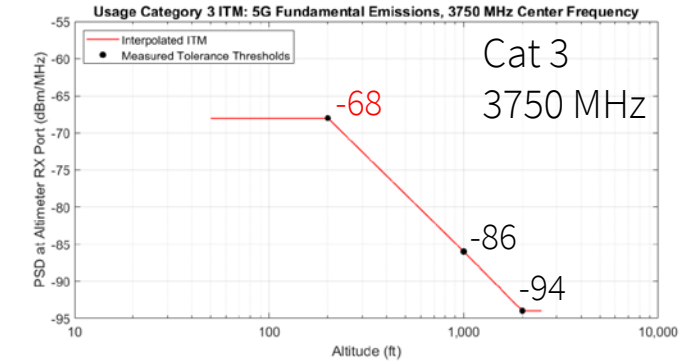


Figure 9-7: Usage Category 3 ITM for 5G Fundamental Emissions at 3750 MHz

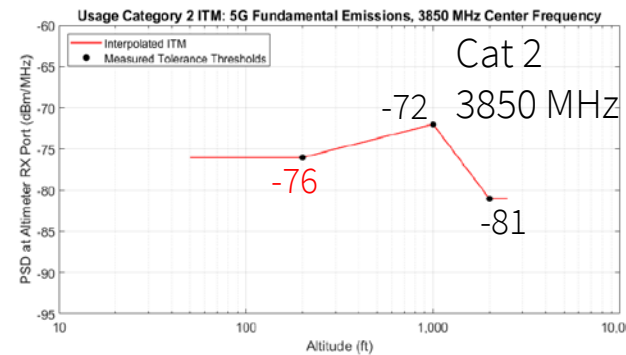


Figure 9-5: Usage Category 2 ITM for 5G Fundamental Emissions at 3850 MHz

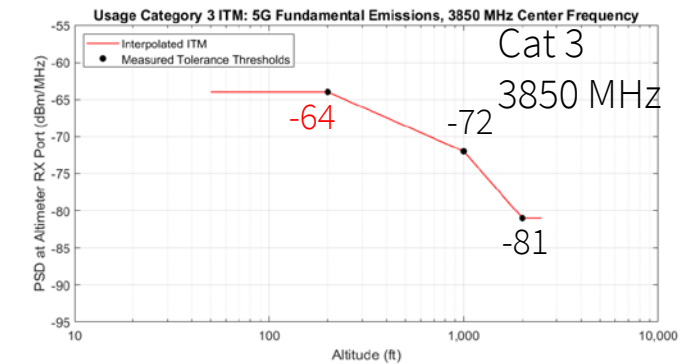


Figure 9-8: Usage Category 3 ITM for 5G Fundamental Emissions at 3850 MHz

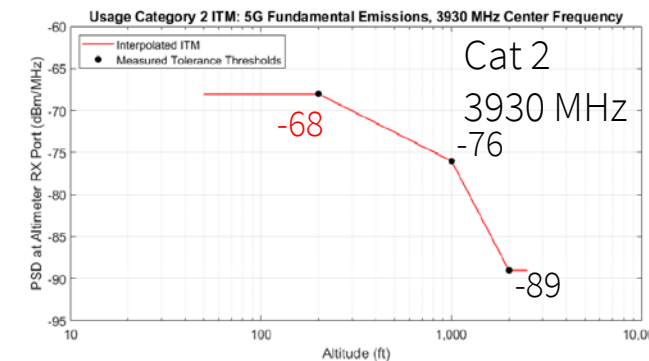


Figure 9-6: Usage Category 2 ITM for 5G Fundamental Emissions at 3930 MHz

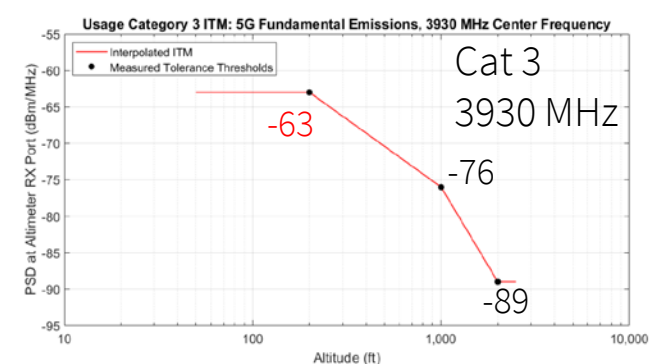


Figure 9-9: Usage Category 3 ITM for 5G Fundamental Emissions at 3930 MHz

Pulsed Altimeters from the 1970s

- The October 1976 issue of Flying Magazine provided a comparison of pulsed and FMCW altimeters for sale at that time (p. 23).
- The pulsed altimeter manufacturers were quoting accuracies of 5% to 10% for the altitudes measured by AVSI – and not specifying the terrain conditions assumed.
- AVSI considered a 2% variance over rough terrain to be an error, yet some manufacturers specified up to a 10% tolerance for a pulsed altimeter.
- Aviation should share information about the poorly performing altimeter that was added late in the process, which is driving their Category 2 and 3 claims.

A point-by-point comparison.					
	Bonzer Mark 10	Hoffman Altiscan	King KRA 405	Sperry AA-210	Collins ALT-50
Range	+ 40 to 2000 ft.	– 10 to 2500 ft.	– 20 to 2000 ft.	0-2500 ft.	– 20 to 2000 ft.
GPW Compatible	No	Yes	No	Yes	Yes
System Type	Pulse	Pulse	FM/CW	Pulse	FM/CW
Weight	4.5 lbs.	8.0 lbs.	10.6 lbs.	9.75 lbs.	9.3 lbs.
Size—R/T	8" W×4" H × 3½" L	2.25" W×5.0" H × 12.5" L	3.00" W×5.25" H × 10.75" L	10.96" W×4.16" H × 7.50" L	3.59" W×3.50" H × 13.91" L
Accuracy	±5%	0-100±2% or 2 ft. 100-2500±5%	0-500±3% 500-2000±5%	0-500±5% 500-2500±10%	0-500±2% or 2 ft. 500-2000±5%
TSO'd	No	Yes	Yes	Yes	Yes
Indicator Mounting	Back only	Front or Back	Front or Back	Front or Back	Front only
List Price	\$2295	\$3600	\$5405	\$5100	\$5496

Some altimeters were undoubtedly designed prior to DO-155's adoption in 1974.
Highlighting added by CTIA to emphasize the pulsed altimeters.

WAIC and 5G In-band Tests are the Same, Yet Aviation Reports Worse Results for 5G, Reflecting Biased Criteria

- The same test was performed in both studies – a vector signal generator injected interference within 4.2-4.4 GHz, and the same altimeters were likely used (RTCA did not disclose the test altimeters for the 5G study).
- The test results ought to be similar.

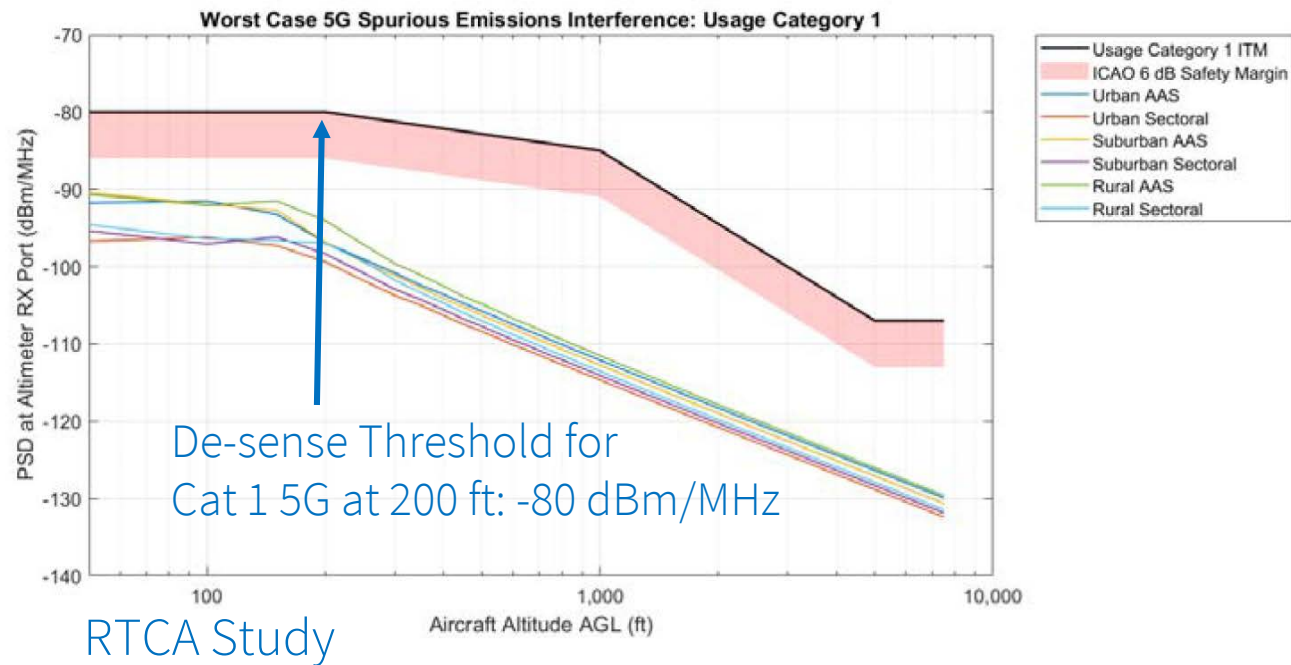


Figure 10-18: Maximum 5G Spurious Emissions Levels, Usage Category 1

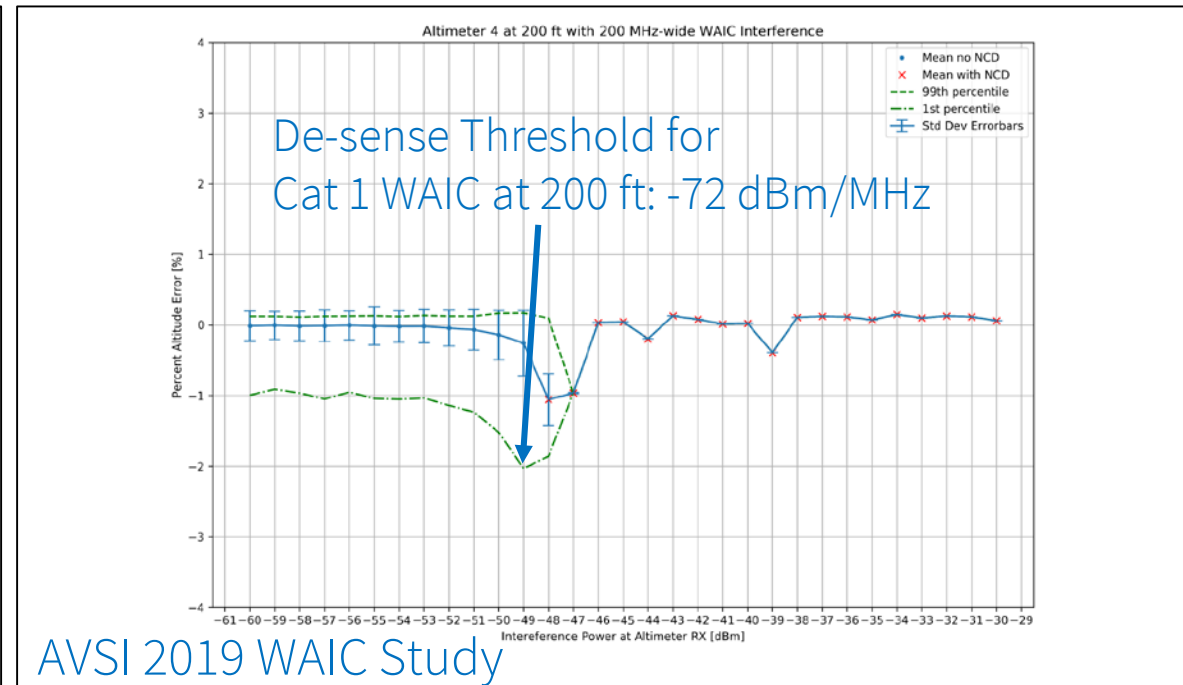


Figure 15: Test results for RA Type 4 (nominal test altitude: 200 feet, loop loss: 92 dB)
(RA Type 4 reports NCD for aggregate WAIC interference power levels above -48 dBm).

Instead, there is an 8 dB difference. Conditions not specific to 5G were made artificially worse to show a more negative result.

WAIC Would Cause Interference to the Worst, Questionable Altimeter

- If aviation were to assess the impact of WAIC on the worst Category 2/3 altimeter, then WAIC would exceed the AVSI-reported ITM for that altimeter by 34 dB.
 - CTIA added the Cat 1 and Cat 2 labels, and added the dark red line corresponding to the Cat 2 ITM reported by AVSI in the 5G study.
 - The difference between the Cat 2 threshold of -89 dBm and -55 dBm, AVSI's modeled WAIC signal level, is 34 dB.
- If the RTCA Report were correct, then WAIC would represent an interference threat to that worst altimeter – yet, this service has already been approved at WRC-2015 to operate within the same spectrum allocation as altimeters.
- This further illustrates how WCLS at 200 ft is an unrealistic scenario, and the outlier altimeter's results should be discarded.

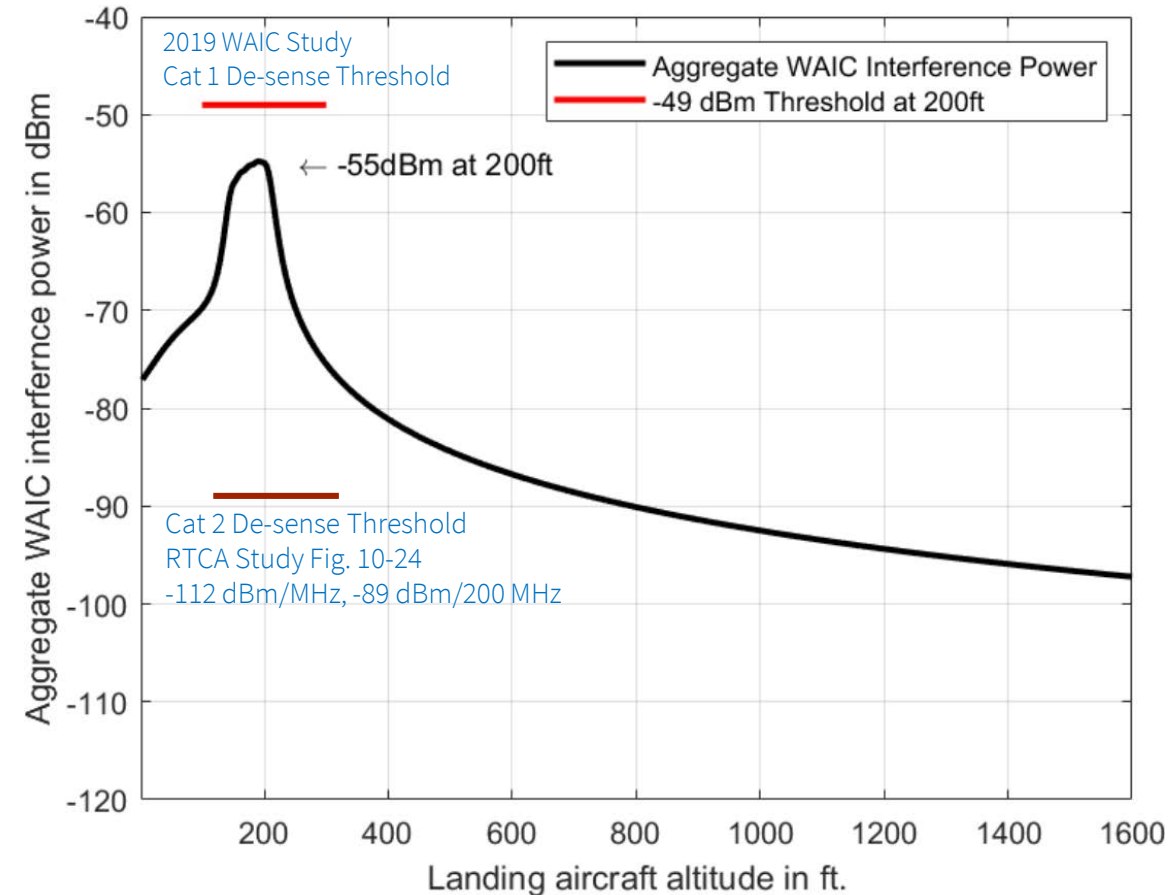
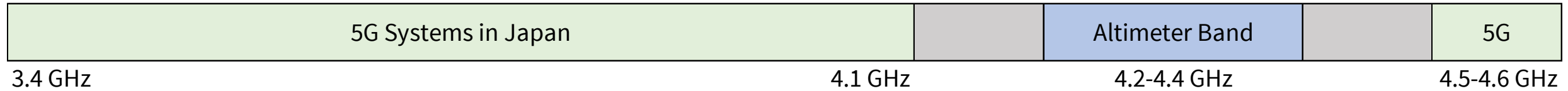


Figure 17: Aggregate WAIC interference power

Figure from AVSI 2019 WAIC Study

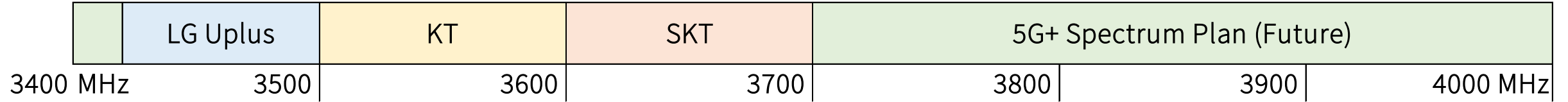
Global Developments

Japan



- Japan has 90,000 5G sites in service.
- Frequency separation is 100 megahertz, less than half of the 220 megahertz separation in the United States.
- No exclusions or power restrictions apply to 4 GHz and below.
 - A base station exclusion zone applies within the closest 100 MHz channels, e.g. 4.0-4.1 GHz, for 1 km x 200 m around airport landing approaches.
- No known reports of interference.

South Korea



- South Korea has deployed 195,000 5G sites in 3400-3700 MHz.
- No mitigations or exclusions are in place.
- No known reports of interference.

Europe

- CEPT in Europe has harmonized 3.4-3.8 GHz for 5G spectrum auctions and deployments. The upper 100 megahertz, 3.7-3.8 GHz, is identical to the lowest 100 megahertz auctioned in the United States.
- **Finland's** carrier Elisa launched 5G service in the 3.4-3.8 GHz band [in 2018](#), with no interference complaints attributed to 5G*.
- **Switzerland's** Swisscom launched 5G in the 3.4-3.8 GHz band [in 2019](#), with no altimeter interference complaints.
- **Norway's** Telenor launched 5G in the 3.4-3.8 GHz band in [March 2020](#), with no interference complaints.
- In **Italy**, Vodafone and other carriers have offered 5G service in the 3.4-3.8 GHz band [since 2019](#), with no interference complaints.
- **Romania's** Digi carrier launched 5G services in 3.6-3.8 GHz [in 2019](#), with no reports of interference.
- In **Spain**, Vodafone, Masmovil, and Telefonica have all launched [5G service](#) in 3.4-3.8 GHz, with no reports of interference to aviation.
- [Three carriers](#) in **Ireland** have launched 5G in 3.4-3.8 GHz, with no reports of interference.
- **Hungary** has [launched](#) 5G service in the 3.4-3.8 GHz band, with no reports of interference.
- Since 2018, [O2](#) has provided 5G service in the **Czech Republic** using the 3.7 GHz band, with no complaints.

Conclusions

Conclusions

- RTCA took the worst case of every input and combined them into a single scenario; the result is something that would never happen in the real world:
 - The landing aircraft would be over the runway, but at a height far exceeding what is allowed by the FAA for landing. (FAA Order 8260.3E).
 - The aircraft would also be rolling 20 degrees while landing, at low altitudes where such a maneuver is dangerous to flight safety.
 - Even though the airplane was flying over the runway, RTCA assumed the worst terrain type for radar reflections underneath the aircraft, such as sand or tilled earth. At the same time, RTCA assumed perfectly reflecting terrain to direct radar signals from the 14 transmitting radar altimeters on the taxiway and apron toward the landing aircraft.
 - The 5G signal level RTCA used in this unrealistic scenario would require placing the 5G tower in a location that violates FAA rules about obstructions to air navigation, and assumed the entire base station power was pointed directly at the aircraft.
 - 18 dB of unwarranted margin and cable loss is further added onto this scenario to reach RTCA's conclusions.

Conclusions

- Multiple technical errors contributed to the significant exaggeration reflected in the RTCA Study.
- Correcting for these errors more than negates all of RTCA's claims of harmful interference for real-world landing scenarios and across all tested usage categories.
- 5G has been successfully deployed across the globe (in some instances with a smaller guard band than will be present in the U.S.) without reports of harmful interference – further underscoring the flaws in RTCA's conclusions.
- The Commission should reject the assertions made by the aviation industry in the RTCA Report.

ctiaTM

The logo consists of the lowercase text "ctia" in a white, sans-serif font, followed by a trademark symbol (TM). Below the text is a horizontal row of seven white dots of uniform size.